

Natural Regions in Western Australia, by E. de C. Clarke

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I. Introduction.

“A land of sin, sand and sorrow”—this alliterative misnomer is still, half in jest, often applied to Western Australia. Many in this State and a few outside it know that it is a land of considerable, yet only partly explored possibilities and one which cannot be justly described or appraised in a phrase, however catching. It is, in fact, divisible into a number of “natural regions,” each more or less clearly marked off by a combination of circumstances, climatic, geographic and geologic.

This paper is an attempt at such a sub-division, made in the hope that it will arouse some interest and discussion, and not in the belief that it is in any sense final. Such discussion will be of practical value if it draws attention to the unsuspected possibilities of some little known area, or even performs the thankless, but none the less useful, task of pointing out the “nakedness of the land” to the over-optimistic.

Among the many who have helped in various ways, I am especially indebted to Messrs. T. Blatchford and H. W. B. Talbot for information regarding many little known parts of the State, to Mr. E. J. Nankivell for a description of the Carnarvon region, to Miss L. V. Hosking and Messrs. G. S. Compton and Wallace Clubb for reading the paper in manuscript and making many helpful suggestions, and to Dr. Dudley Stamp for invaluable advice regarding the form of the paper.

II. Method of Division.

The natural regions distinguished in this paper are selected in the following way:—

- A. The State may be primarily divided into *major physical regions*.

B. It may again be divided into *major geological regions*. These may be expected to effect a sub-division of the major physical regions, but to harmonize broadly with those physical regions.

C. *Climatic considerations*, chiefly the amount and season of rainfall, will be found to necessitate further division of the areas arrived at by A. and B.

By this stage we should have arrived at a classification into natural regions and our result should be in harmony with the distribution of distinctive plant associations.

A. In the broadest way this State can only be divided into two physical regions (Jutson, 1914, p. 19): (1) A low lying narrow strip running almost continuously along the coast from near Albany to Broome. (2) A tableland occupying the whole interior of the State.

B. Geologically Western Australia may be divided broadly into:—

- (1) Western coastal strip of Carboniferous or later age.
- (2) South-central Pre-Cambrian (chiefly Archaeozoic) shield—mineral bearing, especially in its eastern part.
- (3) South-eastern area (Cretaceous and later), which may be sub-divided into a northern part, in which the rocks are mainly sandy, and a southern, in which they are calcareous.
- (4) Eastern Pre-Cambrian area.
- (5) North-western Pre-Cambrian area, predominantly Proterozoic, which is further divisible into an eastern section, devoid so far as known of mineral deposits of economic value, and a western, containing patches of earlier Pre-Cambrian which carry minerals of value.
- (6) West Kimberley—predominantly Proterozoic or lower Cambrian.
- (7) East Kimberley—Cambrian-Carboniferous with very large development of basalt.
- (8) Area between (5) and (6)—Cambrian-Carboniferous (predominantly Carboniferous), but with minor development of Mesozoic and Cainozoic rocks.

C. Climatic (rainfall) considerations, together with vegetational characteristics lead to further sub-divisions, which need not be particularised since they are shown summarily in the following tabular arrangement:—

Physical Strips	Geological	Climatic	Natural Region.
Coastal Strips	<p>Tertiary and later at surface underlain by Mesozoic and Palaeozoic (artesian).</p> <p>Palaeozoic and Mesozoic Coastal tableland.</p>	<p>Northern Summer Rain.</p> <p>Southern Winter Rain.</p> <p>Southern Winter Rain.</p>	<p>Carnarvon (8)</p> <p>Perth (4)</p> <p>Greenough (5)</p>
	<p>Palaeozoic (chiefly Carboniferous) central belt.</p> <p>Palaeozoic (chiefly Cambrian) N.E. area</p>	<p>Southern, low rainfall.</p> <p>Northern, monsoonal.</p> <p>Monsoonal</p>	<p>Canning (12)</p> <p>Fitzroy (13)</p> <p>Antrim (15)</p>
Plateau.	<p>Later Mesozoic and Tertiary { Calcareous (upper) portion (sub-artesian). Sandy (lower) portion.</p> <p>Younger Pre-Cambrian or Lower Cambrian (no known minerals of economic value).</p>	<p>Winter rain.</p> <p>Summer rain (small). }</p> <p>East-Central, dry.</p> <p>North Kimberley, monsoonal.</p>	<p>Nullarbor (1)</p> <p>Carnegie (9)</p> <p>North Kimberley (14)</p> <p>Murchison (7)</p>
	<p>Older Pre-Cambrian Central Shield (minerals of economic value).</p>	<p>Northern, mainly summer rain, predominant Mulga vegetation.</p> <p>Central, winter rain predominant Eucalypt vegetation.</p>	<p>Kalgoorlie (6)</p> <p>Wheat Belt (2)</p>
	<p>Older Pre-Cambrian eastern area.</p> <p>Mixture of Older and Younger Pre-Cambrian (minerals of economic value).</p>	<p>South-western, winter rain, 10in.-25in., Salmon, York and Morrell association.</p> <p>South-western winter rain, 25in. or more, Jarrah association.</p> <p>Summer rain.</p>	<p>Jarrah Belt (3)</p> <p>Warburton (10)</p> <p>North-West (11)</p>

III. Description of the Natural Regions.

1. *Nullarbor.* Geologically, this region is very simple and uniform, being composed of Tertiary limestones underlain by sandy rocks (Maitland, 1919, a., p. 48), from which in places is obtained sub-artesian water of poor quality. Equally simple is the topography of the great treeless plain traversed by the Trans-Australian railway. The vegetation, at least from the general observer's point of view, is sparse and uniform. The rainfall is less than 10 inches except along a narrow coastal strip which is neither large enough nor sufficiently distinct in its possibilities to be separated regionally from the limestone country farther inland. The Nullarbor Region seems unlikely ever to support more than a very sparse pastoral community.

2. *The Wheat Belt.* This region includes the Yilgarn Goldfield with the mining centres of Southern Cross, Bullfinch and Westonia of which complete geological surveys are available (Blatchford and Honman, 1917, and literature there cited), but most of the remainder, except the gold-copper centre Ravensthorpe, has still to be prospected and geologically surveyed. So far as known, the area is composed of crystalline rocks, chiefly acid, but with minor developments of dark coloured basic rocks in which most of the mineral wealth occurs. These rocks are supposed to be Pre-Cambrian, although there is no clear proof of their age (Clarke, 1924, p. 15). Along the southern coast are patches of Tertiary or still later rocks covering areas too small to be separated in this discussion. Topographically this region is the southern part of the Great Plateau of Western Australia (Jutson, 1914, p. 19), and presents the usual characteristics of that upraised peneplain, including the oft-described salt "lakes." Near the coast the topography becomes more varied, with several inlets indicating recent depression, and with conspicuous east-and-west trending ranges (the Barrens). In this southern part of the region Mallee thickets (Gardner, 1923, Vol. VII, p. 43) are perhaps more abundant than elsewhere in the State. The soil is more fertile than that of the Nullarbor region—as follows from the nature of its constituent rocks. The average annual rainfall ranges from 10 to 20 inches, and most of it falls in the winter. The predominant vegetation of this region is the Salmon Gum-Morrel association to the east, passing into the Wandoo on the west, which in turn grades into the Jarrah forest of the "South-West" outside the limits of the region (Gardner, Vol. VII, p. 40). The eastern portion of the wheat belt is, despite a slightly smaller rainfall, more easily settled than the Wandoo section, which suffers from the disability of being the chief "poison country" of the State. "Nearly all the known poison plants belonging to *Gastrolobium* and *Oxylobium* are characteristic of Wandoo under-

growth and consequently the country has not been settled to the same extent as the Jam country or the Salmon Gum country farther east" (Gardner, Vol. VII, p. 40). The extent of this region, shown on the accompanying map (Pl. XV), is greater than that of the Wheat Belt on the Agricultural Department's map (Sutton), or in McLintock's "Swan Geography" (p. 116), but there seems no reason, having consideration for annual rainfall, time of incidence of rain, and regularity, for regarding the eastern boundary of profitable wheat-growing as coming much short of the 10" isohyet.

A serious drawback shared by several regions to be later described is the saltiness of the ground-water and the absence of any artesian supply. The supply of water is therefore entirely that which is held by surface storage—natural or artificial.

3. *The Jarrah Region.* This region has been geologically mapped only in small patches. It appears to consist essentially of metamorphic rocks (gneisses, etc.) seamed with basic dykes, the complex being thought to be of Pre-Cambrian age. The higher ground is nearly everywhere capped with laterite. Lateritic deposits, indeed, occur in many other parts of the State, but they are most extensively developed in the Jarrah Region. The soil formed by the weathering of the basic rocks is the most fertile. Over incoherent laterite the soil is slightly better than that derived from the more acid rocks, but where, as is usually the case, the laterite is cemented into a "craie"; it bars the downward growth of the roots of most cultivated plants and consequently laterite country is generally unsuited for cultivation. It is, however, on the laterite that the Jarrah (*Eucalyptus marginata*) grows best (Gardner, 1923-25, Vol. VI, p. 104). The region is named after its most important product, but includes more than the "prime" Jarrah area (see Gardner, *op. cit.*).

Comparatively small areas of down-faulted Permo-Carboniferous sediments carrying coal seams occur at Collie and at Wilga (a few miles south of Collie), and are of economic importance (Maitland, 1919, (a), p. 38, 1919, (b), p. 3).

The western part of this region is the dissected western margin of the Great Plateau of Western Australia (Jutson, 1914, p. 19) bounded on the west by the Darling Fault. The topography near the fault-line scarp is somewhat rugged, passing in a distance of 5 miles or so to the east into the more gently undulating contours of the eastern part of the region, which in turn merge into the still more monotonous landscape of the Wheat Belt. This region has a rainfall, predominantly winter and remarkably regular, of between 25 and 40 inches per annum.

The most valuable forests of the State occur in this region, Jarrah and Karri being of greatest importance.

Climate and topography combine to make the Jarrah Region almost immune from the water supply problem. The streams traversing the line of the Darling fault, in deep, steep-sided valleys, are admirably suited for the construction of dams which will furnish water to the region described next. Many of these streams are perennial. Well water of fair quality, but limited quantity, is also available in many places. In this region, however, as also in the main Wheat Belt, clearing and cultivation lead to an increase in soil salinity (Wood, 1924).

4. *Perth Region.* Geologically, this region consists of practically undisturbed sands, clays and limestones, of Recent and Tertiary age, over-lying Mesozoic and Palaeozoic sediments, which are thought to dip gently S.W., but are not known to outcrop in the region. The most important water carriers of the artesian province which is roughly coterminous with the Perth Region, are thought to be the Jurassic sandstones (Maitland, 1919 (a), p. 6).

The country is undulating, with inconspicuously scattered sand-hills now fixed by vegetation or cemented by carbonate of lime, except along the actual sea margin. The limestones formed by this cementation resist rain-wash better than the sands and stand up as low hills. Many ponds and small lakes occur in chance hollows among the sand dunes, and some of these have advanced to the stage of peat swamps, which form rich soil when drained.

The sub-recent elevation which was responsible for the emergence of the coastal plain has been followed by a slight depression giving shallow estuaries at many of the river mouths.

Very few of the rivers carry any fresh water to the sea during the summer. As a result of this intermittent flow, sea-built sand bars obstruct the estuaries, whose value as harbours is thus much lessened. Moreover, the consequent ponding back of the river water causes rise of the water table and water-logging of the neighbouring low-lying country (Shields, p. 2). Water for use in the more densely settled parts is being increasingly drawn from reservoirs in the Darling Range (Jarrah Region). The Perth region is however an artesian water basin (as already noted), and, moreover, has an abundant supply of ground water at shallow depths.

The eastern margin of this region, where the soil is partly derived from acid and partly from basic rocks, is fertile (Woolnough, p. 16), being the chief vine-growing belt in the State. The outer

portion, although excessively sandy, is nevertheless stated to be suitable both for dairying and market gardening when worked in conjunction with the intervening swamps.

5. *Greenough Region.* This may be described as a tableland of Jurassic sandstone dissected by well-defined watercourses which have in places reduced the tableland to groups of mesas and buttes overlooking plain country formed of older rocks. The sandstones produce a poor soil, and it is the more fertile areas of exposed Permo-Carboniferous and older rocks that are settled. On the seaward side of the dissected Jurassic tableland is a rather narrow fringe of lower-lying ground, which probably has, except for its lighter rainfall, the same characteristics and possibilities as the Swan Region. In places where the Jurassic rocks have been removed, ancient 'Pre-Cambrians' are exposed, in which, in the Northampton district, are notable occurrences of lead ore.

The annual rainfall of the Greenough Region is 15-20 inches, nearly all of which falls in winter. The region therefore comes climatically within the Wheat Belt. On the Jurassic rocks there is good ground-water close to the surface, but on the more fertile older rocks the ground-water is saline and generally ununsable. In this portion reliance has to be placed on excavated tanks.

Some fodder plant may yet be found which will grow freely in the sandy soil yielded by the Jurassic rocks, but until such a discovery is made the region must remain almost uninhabited.

Coal seams are known in the Permo-Carboniferous rocks (Campbell, 1910), but their economic possibilities have yet to be proved.

6. *Kalgoorlie Region.* This part of the State is composed of ancient crystalline rocks, mainly acid, through which are scattered lenses of basic rocks which cover about one-fifth of the region and carry the chief gold deposits of Western Australia. The topography and vegetation are like those of the Wheat Belt, except that in the Kalgoorlie Region the ranges of N.W.-trending hills marking lenses of basic rock are somewhat more prominent and abundant. It is marked off from the Nullarbor Region by geologic, and from the Wheat Belt by climatic characters, its rainfall being less than 10 inches.

Considering its climate, the Kalgoorlie Region has been very fortunate in having, in the Salmon Gum forest ample supplies of good mining timber and firewood. Without these the difficulty and expense of mining development would have been so much greater that one is almost justified in saying that there could not have been a "Golden Mile."

Salt "Lakes" (Jutson, 1914, p. 20) are the most marked physiographic feature of the region, but this it shares with the Wheat Belt and with the Murchison Region to be next described. Defined watercourses are rare, inconspicuous, and very seldom contain water.

The ground water is almost everywhere too salt for use. The majority of the population obtains water from the Mundaring Reservoir in the Darling Range (Jarrah Region), whence between 3 and 4 million gallons are pumped daily. The total length of main pipe line is 380 miles and it supplies en route 30 towns and has 493 agricultural extensions. Away from the pipe-line, water must be obtained either from natural reservoirs (guamma and rock-holes and intermittent soaks—Jutson, 1914, p. 129 and literature there cited) or from artificial reservoirs.

The rainfall is best estimated at less than 10 inches per annum. It is true that several places show an average, calculated from records over a number of years, of 10 inches or more, but this is probably due to local thunderstorms. It seems unlikely that any activity requiring more than a 10-inch rainfall can be permanently established. When the forest is removed for mining firewood and timber the soil supports a more abundant and attractive growth of the salt-bush and grass on which sheep and cattle thrive. This region is, therefore, destined ultimately to become a sparsely settled pastoral area, but at present its mineral production is more important. From the beginning of mining activity up to the end of 1925, the East Coolgardie Goldfield, i.e., mainly the mines of the "Golden Mile," had produced, from nearly 31 million tons of ore, 19½ million fine ounces of gold, valued at 82¾ million pounds sterling. Although for many years production has declined for various reasons—some not connected with the value of the mineral deposits—it will long remain an important gold producer.

This region, with the Wheat Belt region, constitutes the most important sandal-wood area of the State.

7. *Murchison Region.* In geology and topography this is essentially similar to the Kalgoorlie Region, but the relief is somewhat more pronounced, "breakaways," for example, being a far commoner feature (for general discussion of breakaways, see Talbot, 1917, p. 43). Rainfall differs little in amount from that of the Kalgoorlie Region, but we are now passing into the regions of summer rainfall. In vegetation and water supply, moreover, there is marked contrast to the Kalgoorlie Region. Throughout "the Murchison," except of course right on the margins of salt lakes, potable water can almost invariably be obtained at depths of less than 100 feet, and the predominant plant association is the Mulga (Gardner, 1923-25, Vol. VII, p. 256), in contrast to the Salmon

Gum association of the Kalgoorlie Region. It should be noted, however, that the Spinifex association so characteristic of the country to the east, makes considerable inroads into the Murchison Region.

Although much mineral wealth has been and will be obtained in this region, it was first settled by pastoralists and is now the most important sheep-carrying area of the State. It has greater drought resistance than the Kalgoorlie Region because of the almost universal presence both of good well-water and edible shrubs. The N.E. boundary has been extended to long. 124°, lat. 26°, into an area of probably Proterozoic rocks, so as to include the good pastoral country of Wongawall (Talbot, 1920, p. 16), which seems less out of place here than in the Carnegie Region.

8. *Carnarvon Region.* This region is entirely composed of sedimentary rocks with, generally, a gentle westerly dip, but there is, according to Mr. E. J. Nankivell, gentle folding along a N.N.W. axis between the Wooramel and Minilya rivers. It coincides with the North-West Artesian Basin (Maitland, 1919, c.), and is thus very definitely distinct from the country to the north. Its oldest and easternmost rocks are "Permo-Carboniferous," followed by Jurassic, which are in turn overlain by Cretaceous and younger rocks.

Its southern portion, lying on the border between areas of summer and winter rain, has an average annual rainfall of less than 10 inches, and the rainfall shows wide variation from year to year. The northern portion has an average of more than 10 inches, and lies distinctly within the area of summer rain. However, in view of the persistence of other characters, this difference in rainfall is not sufficient ground for dividing the area into two regions.

I am indebted to Mr. E. J. Nankivell for a description of the topography and vegetation. The region seems particularly difficult to describe in a general way. Its relief is mild, the hills, which are residuals of erosion of the cuesta or escarpment or butte type, are neither lofty nor numerous, but, though they rise only in a few places as much as 1000 feet above sea-level, they are very conspicuous because of their steepness. The soil is predominantly sand or sandy loam, but clay soils are fairly common in the southern portion, and in some places are areas of limestone-derived soil. Much of the country is therefore very porous, and consequently reticulation from artesian wells is costly. The entire region is described as excellent pastoral country, although in parts there is the water-supply difficulty just mentioned, and in the northern section the water so far obtained is said to be generally saline.

The covering of shrubs—chiefly Mulga and other Leguminosae—is fairly dense in the southern portion, and is of value as fodder,

particularly in times of drought. North of the Wooramel River (lat. 26°) the country, though still excellent pastorally, is more sparsely shrubbed.

It is generally thought that this Region will remain a lightly settled pastoral area, although a map (1924) and pamphlet (1924, p. 25) issued by the Department of the North-West, suggest the possibility of the development in its coastal portion of tropical agriculture by means of irrigation.

9. *Carnegie Region.* This area may be known by the name of the first explorer to traverse it thoroughly (Carnegie, 1898). Its southern part is, so far as known, made up of late Mesozoic or early Tertiary sediments, which dip gently south and are the water-bearing beds of the Nullarbor Region (Maitland, 1919 (a), fig. 70, p. 46 and p. 49). The northern part, which has not been geologically mapped, is probably in part composed of the same Mesozoic and later rocks and, in part, of the much older Nullagine System. As noted later, its western boundary, against the Canning Region, has not yet been defined.

The rolling sandhill country, clothed with spinifex, dotted with "desert gums," and interrupted here and there by "breakaways," was described with much aversion by its first explorers. Those who have more recently crossed it, well-equipped both materially and also with the experience of the pioneers, have not found the "hateful spinifex" country as forbidding as might be expected (Talbot, 1917, pp. 16-17, 22-38).

A few salt lakes are known to occur in this area. We are too ignorant regarding their outline to attempt the reconstruction from them of a dismembered river system, as has been done by Gregory (1907) for the Kalgoorlie, Murchison and other regions. Water-courses are absent except in and near the "breakaways." The natural waters are gnamma- and rock-holes and a few evanescent soaks. The absence of native wells is in strong contrast to their abundance in the adjoining Canning Region to be presently described. No wells have been sunk in this country and we have, therefore, no direct knowledge of the nature of the water supply. From what is known of the geology, it would appear that, being situated partly on the intake beds of the Eucla artesian basin, this region will not yield artesian water.

Our knowledge of the Carnegie Region is very meagre. What we do know indicates that it is an area of no mineral wealth and is pastorally practically valueless.

10. *Warburton Region.* This region, which possibly extends as far north as Lake Macdonald (lat. 23° 30') is mainly composed of

acid metamorphic and gneissic rocks, supposedly Pre-Cambrian, together with a minor amount of Nullagine (?) sediments, but there is amongst them a notable development of two types of basic igneous rock, one a "Greenstone," similar to the greenstones of the Kalgoorlie and Murchison regions, the other unaltered dolerites and gabbros (Talbot, 1917). In the character of its vegetation the Warburton Region recalls the Murchison. Topographically, the tableland of the Carnegie Region is continued into the Warburton, but above the general level rise ranges, some in the old crystalline rocks, some in the later dolerites and gabbros, some in the hard Nullagine sandstones. Draining from these hills and losing themselves in the sandhill country of the Carnegie Region to north, west, and south, are several well-defined watercourses.

One shallow well with a large supply of potable water is known, and good springs have been noted in several localities. Probably good stock water is easily obtainable in most parts of the Region.

The region would be as successful pastorally as the Murchison (Talbot, 1917, p. 118), and there are hopes that payable deposits of gold will be discovered, but its relatively small size and inaccessibility will hinder its development for many years.

11. *North West Region.* This large area, traversed by several more or less parallel rivers (De Grey, Fortescue, and Ashburton), includes a variety of geological formations of assumed Pre-Cambrian age, namely, the almost horizontal Nullagine System which occupies about three-quarters of the region, the more steeply inclined but little metamorphosed Mosquito Creek Series, and the highly altered "greenstones" and intervening granites composing the northern portion, in which there are widespread and varied mineral deposits, including copper, tin, lead, tantalite, asbestos, and gold.

The topography of the area is naturally a reflection of its geology, so that whereas in the southern part mesas and buttes are characteristic, in the northern part the scenery varies. As in the Kalgoorlie and Murchison Regions, granite country is flat or gently undulating; "mineral belts," such as Marble Bar, Nullagine, Braeside (lat. 21°, long 121°), and Lionel, near Nullagine, are, in a small way, very rugged.

However, these geological and topographical differences are too intermingled to justify the separation of the area into two or more regions of individuality equal to the others described in this paper. Perhaps the factor which overrides geological differences is the prevalence throughout the region of uncertain summer rainfall.

As to vegetation, the region is characterised by the predominance of the *Spinifex* association, the Mulga, so characteristic of the

Murchison, being here only sporadic. The northern boundary of the Mulga is approximately (Gardner, 1923-25, Vol. VII, p. 256) marked by a line from the junction of the Lyons and Gaseoyne rivers to Wilma. The Spinifex is largely of the "soft" variety, which I am told by Mr. C. A. Gardner is probably a different species from the "buck" spinifex (*Triodia pungens*) and which has considerable fodder value. However, the comparative absence of shrubs and trees, edible or shade-giving or both, makes this region far less drought-resistant than the Murchison. Water is obtained from wells and pools in the watercourses; there is no artesian water in the region.

The chief industries of this area are and will continue to be pastoral and mining, although, according to the map (1924) issued by the Department of the North West, the coastal portion may be suitable for tropical agriculture under irrigation.

12. *Canning Region.* Almost all our knowledge of this region, called after Mr. A. W. Canning, who laid out a practicable stock route across it, is derived from Talbot's report (1910). Geologically it is an area of Permo-Carboniferous and older sediments, arranged in gentle folds. These rocks are largely masked by a covering of sand-dunes. How far it extends eastward is unknown (Clapp, p. 226). As already noted, this region is distinguished from the Carnegie by its sprinkling of "native wells" which, though perhaps mostly mere "soaks," at any rate indicate a more accessible water supply (cp. Clapp, p. 230). The most hopeful feature of this Region is that it is an artesian basin (Maitland, 1919 c., pp. 4 and 5), and may, therefore, become sparsely settled by pastoralists. Of late, also, it has been reported to possess some of the structural characters of an oil-bearing region.

Wallal Sub-Region. This narrow belt of sandy country bordering on the "Ninety-Mile Beach" has been mapped as Tertiary and Recent in age. Topographically it seems distinct from the Canning Region, from which it also differs in that its ground water is shallow and abundant, and by the fact that it supports a good growth of couch-like grass. This sub-region is all selected by pastoralists (Station Map, 1924), in striking contrast to the Canning country inland. Further description will be found in Clapp's paper (pp. 212, 228, 229, 230).

The portion of the State which still remains to be regionally classified is the Kimberley Land Division. For the western part we have recent botanical reports by Gardner (1923 and 1925, Vol. VIII), who recognises seven plant formations:—

- (a) Savannah Woodlands covering country east and north of the King Leopold Range except that occupied by (d).

- (b) River forest—along the river beds in (a).
- (c) Mangrove forest—along the coast line.
- (d) Northern sclerophyllous woodlands—in the north-west corner of (a).
- (e) Littoral forest—a narrow coastal strip particularly marked near the Prince Regent River.
- (f) Grasslands—principally on the plains of the Lennard, May, Meda, and Isdell rivers.
- (g) Pindan (low sclerophyllous woodland) characteristic of the south-west part of the Kimberley, east of Broome.

Of these the River, Mangrove, and Littoral forest cover small areas and can hardly be said to constitute natural regions, but the savannah woodlands, northern sclerophyllous woodlands, grasslands, and pindan should be useful guides.

It is suggested that in the Kimberley the following regions may be recognised:—

13. *Fitzroy Region.* This area is essentially composed of Permo-Carboniferous rocks. However, a very large part is covered with a superficial layer of alluvial material brought down by the Fitzroy River and its tributaries. Thus the fertile flats bordering on the Fitzroy and lesser streams (Gardner's "grasslands") differ markedly from the sandier pindan country, which southwards merges gradually into the sandridges of the Canning Region and northwards into the foothills of the Napier and other ranges. Like the Canning region, from which it is distinguished by its greater rainfall, its eastern limit is unknown.

In normal years there is sufficient surface water in the form of "billabongs," etc., for pastoral requirements. The region also has artesian water, being on the northern edge of the "Desert" basin (Maitland, 1919 c., fig. b), but its artesian supplies have been only slightly explored.

This region carries large cattle runs, but is also marked by the Department of the North-West as suited for tropical agriculture, and has for some years been systematically prospected for petroleum with fairly satisfactory results.

14. *North Kimberley Region.* The greater part of this region, which is vividly described by Easton (1922), is occupied by sandstones and basic igneous rocks, either later Pre-Cambrian or Lower Cambrian in age (Maitland, 1919 a., Geological Map; Wade, 1924, p. 14 and Geological Map). There is, however, a southern fringe of ancient crystalline rocks, in which in 1884 was made the first im-

portant gold find in the State. Jutson (1914, p. 76) terms the region an uplifted and dissected peneplain. Later subsidence has "drowned" the rivers for many miles above their mouths and has produced several good harbours, which are of little present value owing to the inaccessibility of the tableland from the deep gorges (Easton, 1922, p. 25). The annual rainfall is at least 20 inches, practically all of which falls in summer. Gardner describes the region under the general term of Savannah Woodland. Feed is abundant, varied, and of better quality than that of other pastoral areas in the Kimberley (Easton, 1922, p. 7). This region will not long remain unsettled by pastoralists, despite the difficulties of transport and the wild character of the aborigines. It does not hold out much prospect of mineral wealth (Easton, 1922, p. 40), but it must be noted that no detailed geological survey has ever been made, and that published information (Maitland, 1902, pp. 8 and 9) is small. In this connection Wade's remarks (1924, p. 39) may be noted.

In the north-west corner of this region is an area marked off by Gardner (1923, p. 19) as sclerophyllous rain forest, which is distinguishable from the savannah woodland by its more slender and more abundant trees, by the presence of harsh Xerophilous shrubs in its undergrowth, and by the comparative scarcity of grass. Pastorally, this area is inferior to the savannah country, and should possibly be separated as a sub-region.

15. *Antrim Region.* In strong contrast to the rugged topography of the North Kimberley are the open "downs" of this region (named from the Antrim Plateau, which constitutes most of it), which no doubt extend far into the Northern Territory. The western boundary, I am informed by Mr. T. Blatchford, follows closely the line separating the rugged Pre-Cambrian or older Cambrian from Upper Cambrian and later rocks, which tend to wear away into great open rolling expanses above which rise a few buttes and small mesas like Mt. Pantou. The rainfall ranges from 20 to 40 inches and is, as elsewhere in the Kimberley, of the summer monsoonal type. It seems possible that, in the northern part, the alluvial flats will prove suitable for tropical agriculture. At present the sole industry is the raising of cattle. Like the Fitzroy region, this area, also, may yet prove to contain oil in payable quantities.

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EXPLANATION OF PLATE XV.

Outline of Western Australia, showing Natural Regions, to be placed over map of Western Australia showing Rainfall and broad Geological Divisions.